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FURTHER CULTURES OF HETEROECIOUS RUSTS[1]

W. P. Fraser

Field observations extending over several years, and culture experiments during the spring of 1911, furnished evidence that the fern rusts of the genus *Uredinopsis* are heteroecious, and have their aecia on *Abies balsamea;* these aecia being the white-spored forms that have passed as *Peridermium balsameum* Peck. The infection experiments during 1911 were inconclusive, so further experiments which are described in the following pages were undertaken in 1912 to establish if possible the connection of these forms.

The teliosporic material used in all the experiments was collected near Pictou, N. S., and was wintered in the open in small cheese-cloth bags; but the culture experiments with this material were carried on in the greenhouse of Macdonald College. The plants of *Tsuga* and *Abies* used in the experiments were obtained not far distant from the college. They were taken into the greenhouse in early spring, as soon as the frost was out of the ground, and kept in the greenhouse till the young leaves appeared and the plants were in the proper stage for infection. As *Peridermium balsameum* was never collected in the field within several miles of where the plants used in these experiments were obtained, and as a number of trees of *Tsuga* and *Abies* obtained at the same time and place were kept as checks, and all remained free from infection, there seems to be no reasonable doubt that the trees used in the experiments were free from outside infection.

The writer returned to Nova Scotia about the middle of June, and the experiments with aeciosporic material were carried on in the laboratories of Pictou Academy. The ferns used in these experiments at Pictou were obtained a week or two before the experiments were performed. They were selected from a place remote from any known or suspected source of infection and in all cases, as described in the experiments, a number of checks were kept. The writer was thoroughly familiar with the locality, and no fern rust appeared until some weeks after the ferns were obtained, nor did any appear later on the plants surrounding those that had been selected for the experiments.

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[1] Read before the American Phytopathological Society at the Cleveland meeting, Dec. 31, 1912.

The aeciosporic material was all collected near Pictou. At the time of collection no uredinia had developed on the ferns near the trees from which it was collected or anywhere in the vicinity.

The ferns used in the experiments with the aeciosporic material were sprayed with water by means of an atomizer. The aeciospores were then shaken from the shoots on the under side of the leaves of the ferns. The shoots bearing aecia were also suspended above the ferns, and the whole was covered with a belljar for a day or two. This was done in a room separate from where the cultures and checks were kept.

The writer is indebted to Mr. E. M. Duporte and Mr. P. I. Bryce, assistants in the department, for the care of the cultures at Macdonald College during his absence, also to the Commissioners and Dr. R. Maclellan, of Pictou Academy, who in their generous way freely placed the laboratories of that institution at his disposal.

UREDINOPSIS STRUTHIOPTERIDIS Störmer

Teliosporic material of this rust on *Onoclea Struthiopteris* (L.) Hoffm. was suspended above a small plant of *Abies balsamea* (L.) Mill. on May 13. Pycnia were noticed on May 27 which probably appeared earlier, and aecia began to appear on June 1, both in great abundance, practically every leaf of the young shoots being infected. Another sowing in a similar manner on May 28 gave pycnia on June 9, with aecia showing by June 18.

Fresh aeciospores of *Peridermium balsameum* on *Abies balsamea* (L.) Mill., which were collected beside ferns of *Onoclea Struthiopteris* that were badly rusted the previous season, were sown on *Onoclea Struthiopteris, O. sensibilis* L., *Phegopteris Dryopteris* (L.) Fee and *Osmunda Claytoniana* L. on June 27.

Uredinia of *Uredinopsis Struthiopteridis* appeared on *Onoclea Struthiopteris* in abundance on June 6. The spores were oozing out on June 8. The other ferns remained free from infection. Another sowing of a collection also believed from field observation to be connected with *Uredinopsis Struthiopteridis* was made on *Onoclea Struthiopteris* and *Phegopteris Dryopteris* on June 29, with uredinia rather abundant on July 8 on the former and no infection on the latter. A third sowing of a collection similar to the others on *Onoclea Struthiopteris* and *Osmunda Claytoniana* on July 2 produced very abundant infection on *Onoclea Struthiopteris,* the uredinia appearing on July 8. Teliospores were present on July 30. *Osmunda Claytoniana* was not infected. Five pots of *Onoclea Struthiopteris* obtained at the same place and at the same time as those used in the experiments were kept as checks and remained entirely free from infection.

The place where the aeciosporic material was collected was kept under observation, and about a fortnight after the spores of *Peridermium balsameum* were being shed, the ferns of *Onoclea Struthiopteris* which grew immediately beside showed the uredinia of the rust in abundance. The distribution of the uredinia was such that it indicated the *Peridermium* on *Abies* as the source of infection.

UREDINOPSIS OSMUNDAE Magn.

Teliosporic material of this rust on *Osmunda Claytoniana* L. was placed in a moist chamber, and the teliospores germinated freely in a few days. The leaves bearing the germinating telia were then suspended above plants of *Abies balsamea* on May 26. Pycnia were observed on June 10, and aecia on June 18. Five more sowings were made and in all cases the pycnia and aecia of *Peridermium balsameum* followed. In several cases the germinating teliosporic material was placed immediately above the young shoots of *Abies* and these showed marked infection, while the other shoots remained practically free.

Observations in the field strengthened the results of the cultures. Whenever the writer found a very abundant development of the uredinia of this rust on *Osmunda* in early summer it was beneath, or close by, trees of *Abies balsamea* that showed a rich infection of *Peridermium balsameum.* The distribution of the aecia on the trees indicated that infection had come from the rusted ferns of the previous season. These observations were made in a number of places.

UREDINOPSIS ATKINSONII Magn.

Aeciospores of *Peridermium balsameum* from *Abies balsamea* which seemed from field evidence to be connected with this rust on *Aspidium Thelypteris* Sw. were sown on a pot of these ferns on July 1, but without infection. Another sowing on July 3 of similar material gave uredinia which appeared on July 10, but not in great abundance. Three pots of *Aspidium Thelypteris* were kept as checks and remained free from infection. There was some field evidence of the connection of these forms but it was not very pronounced.

UREDINOPSIS PHEGOPTERIDIS Arthur

Teliosporic material of this rust on *Phegopteris Dryopteris* (L.) Fée was suspended in the usual way above *Abies balsamea* on May 27. Pycnia appeared on June 12 followed by aecia. Infection was not marked, only about twenty of the young leaves bearing aecia. Observations in the field also indicated the connection of these forms.

UREDINOPSIS MIRABILIS Magn.

Teliosporic material of this rust on *Onoclea sensibilis* L. was suspended above *Abies balsamea* (L) Mill. on May 13. Pycnia and aecia followed, the latter being first noticed on June 6, about a dozen leaves showing aecia.

Aeciospores (*Peridermium balsameum*) from *Abies balsamea* were sown on two pots of *Onoclea sensibilis* on June 28. Abundant uredinia followed, being first noticed on July 5, the urediniospores were oozing out by July 8.

Another sowing of aeciospores was made on *Onoclea sensibilis, Onoclea Struthiopteris* and *Aspidium Thelypteris* on July 1. Abundant infection of the pot of *Onoclea sensibilis* followed, the uredinia being present on July 8. None of the other ferns showed infection.

Another sowing on *Onoclea sensibilis* on July 3 also gave abundant infection, the uredinia appearing by July 10. Five pots of plants from the same place as those used in the experiments and obtained at the same time were kept as checks and showed no infection.

Observations in the field strengthened the evidence of connection furnished by the cultures. It was noticed for several years that wherever this rust was common on *Onoclea* in the following spring the firs near were abundantly infected with *Peridermium balsameum,* but the sequence of spore forms was not carefully observed. This season several places, where this rust was known to be common on *Onoclea sensibilis* in 1911, were kept under observation. It was found that *Peridermium balsameum* appeared abundantly on the trees of *Abies balsamea* that grew near about June 25. In about ten days uredinia appeared on the ferns of *Onoclea sensibilis* growing immediately beneath, and soon became common.

The experiments and field observations here described seem to the writer to establish the connection of the five species of *Uredinopsis* used in the experiments with the white-spored aecia on *Abies balsamea* which have passed as *Peridermium balsameum.* The question whether these are distinct species with similar aecia or whether they should be included under one species needs further study. It will be noticed that the evidence of cultures, as far as it goes, indicates that the species established are good.

The examination of the cultures and collections of the fern rusts of the genus *Uredinopsis* convinced the writer that the first spore form to appear is the urediniospore. The spores which have been regarded as aeciospores were rarely present in the collections and never appeared first.

In the genus *Hyalopsora* the aeciospores were found to be the first to appear.

PUCCINIASTRUM MYRTILLI (Schum.) Arthur

Teliosporic material of this rust on the leaves of *Vaccinium canadense* Kalm. was suspended on May 28 above a young tree of *Tsuga canadensis* (L.) Carr. Pycnia were observed on a number of leaves on June 10, and aecia began to appear on June

14. The aecia developed rapidly on about fifty of the leaves, and were mature in a few days. The aecia were the deep reddish-yellow form collected abundantly in Nova Scotia in several regions beside *Pucciniastrum Myrtilli* on *Vaccinium canadense* and *V. pennsylvanicum* Lam. which has passed as *Peridermium Peckii* Thüm. but which Arthur regards as distinct.[2]

This confirms the life history of this species as established by Clinton (Report Conn. Agric. Exper. Sta. 1909–1910, p. 719 and MS.) who sowed aeciospores from *Tsuga canadensis* on *Gaylussacia baccata* (Wang) C. Koch. and produced the uredinia of *Pucciniastrum Myrtilli.*

MELAMPSORA MEDUSAE Thüm.

Leaves of *Populus grandidentata* Michx. bearing abundant telia of this rust were placed in a moist chamber and the teliospores gave excellent germination in a few days. A sowing on two plants of *Tsuga canadensis* (L.) Carr. was followed on both plants by pycnia in about a week, and later by aecia.

On July 18, 1912, the cones of a considerable area near Pictou were found to be infected by *Caeoma Abietis-canadensis* Farl., about one half of the cones showing infection. The place was visited about ten days later and the uredinia of *Melampsora Medusae* were abundant on the leaves of *Populus grandidentata* which grew near and beneath the infected trees. These experiments and observations confirm the cultures of last year.[3]

MELAMPSORA ARCTICA Rostr.

Teliosporic material from *Salix* (species undetermined) was placed in a moist chamber until the teliospores germinated when it was suspended above *Abies balsamea* on June 10. Pycnia were noticed on June 24 followed by aecia. This experiment confirms the cultures of the previous season.[4]

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[2] See Mycologia 4: 184. 1912.

[3] See Mycologia 4: 188. 1912.

[4] See Mycologia 4: 187. 1912.

SUMMARY OF CULTURES DESCRIBED IN THIS ARTICLE

1. Life histories established for the first time.

Uredinopsis Struthiopteridis Störmer. Two successful sowings of teliospores from *Onoclea Struthiopteris* (L.) Hoffm. on *Abies balsamea* (L.) Mill. Three successful sowings of aeciospores from *Abies balsamea* on *Onoclea Struthiopteris.*

Uredinopsis Osmundae Magn. Six successful sowings of teliospores from *Osmunda Claytoniana* L. on *Abies balsamea.*

Uredinopsis Atkinsonii Magn. Aeciospores from *Abies balsamea* infected *Aspidium Thelypteris* Sw.

Uredinopsis Phegoteridis Arthur. *Teliospores* from *Phegopteris Dryopteris* (L.) Fee infected *Abies balsamea.*

Uredinopsis mirabilis Magn. Teliospores from *Onoclea sensibilis* L. infected *Abies balsamea.* Three successful sowings of aeciospores from *Abies balsamea* on *Onoclea sensibilis.*

2. Life histories supplementing previous work.

Pucciniastrum Myrtilli (Schum.) Arthur. Teliospores from *Vaccinium canadense* Kalm. infected *Tsuga canadense* (L.) Carr.

Melampsora Medusae Thüm. Teliospores from *Populus grandidentata* Michx. infected *Tsuga canadensis* (L.) Carr.

Melampsora arctica Rostr. Teliospores from *Salix* infected *Abies balsamea* (L.) Mill.

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